KamLAND Status and Prospects

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Work on the first phase of the KamLAND experiment has culminated in the recent appearance, in Physical Review Letters [1], of results corresponding to a 145.1 day reactor anti-neutrino sample. Fifty-four inverse beta decay-like events consistent with electron anti-neutrino interactions were observed while the no-oscillation hypothesis predicts 86.8 ± 5.6 within the sample time period. Assuming a two-flavor oscillation model and CPT invariance, this result is strong evidence (99.95% CL) that neutrino oscillation parameters fall within the Large Mixing Angle (LMA) region of parameter space (Figure 1). An analysis of the solar $\overline{\nu}_e$ flux is forthcoming. In addition, the col-
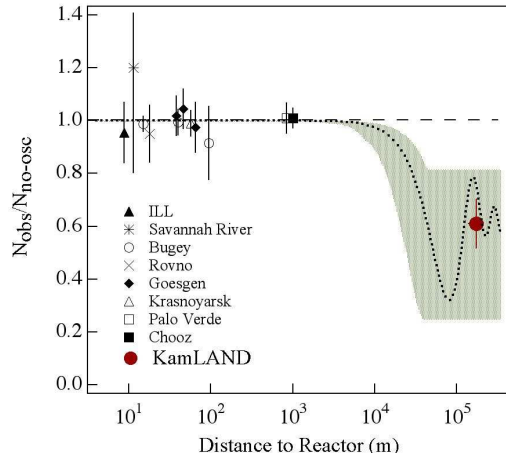

FIG. 1: $N_{obs}/N_{no-oscillations}$ as a function of baseline

laboration is now considering a solar neutrino measurement which would constitute the first direct observation of $^7\text{Be}\ \overline{\nu}_e$s. Such a measurement would require a substantial increase in scintillator purity as the energy threshold for solar ν_e events is extremely low (280 keV). KamLAND is also preparing to make a measurement of the geo-neutrino flux. In order to avoid low energy background from geological $\overline{\nu}_e$s, the reactor analysis cuts require the positron visible energy to be greater than 2.6 MeV. These $\overline{\nu}_e$s are decay products of Uranium and Thorium in the earth's crust and mantle and their distributions are not yet well understood. The current KamLAND best-fit (from the first oscillation result) is consistent with 4 $\overline{\nu}_e$ events from ^{238}U and 5 from ^{232}Th, corresponding to 40 TW of radiated heat assuming model Ia in Figure 2. In

order to properly analyze the lower end of the energy spectrum a detailed survey of the local U and Th dis-
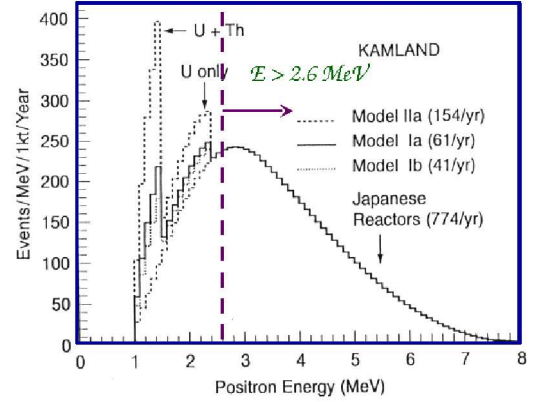

FIG. 2: KamLAND visible energy spectrum and geo $\overline{\nu}_e$ spectrum from theory

tributions in the rocks surrounding the KamLAND site is necessary. When this is completed, KamLAND will be in a position to make important contributions to geophysics as well as neutrino astrophysics [2]. One further category of $\overline{\nu}_e$s, those from supernovæ, will be observable by KamLAND. These $\overline{\nu}_e$s carry with them much information about the formation of the early universe as well as the mechanics of neutrino oscillations. Measurements of this supernovæ relic neutrino (SRN) flux will be sensitive to the neutrino mass hierarchy as well as the last unmeasured neutrino mixing angle, θ_{13}. For the purposes of an SRN measurement, KamLAND's sensitivity to $\overline{\nu}_e$ interactions is supplemented by the fact that no scintillator purification or infrastructure development beyond current levels is necessary, since the energies of $\overline{\nu}_e$s originating from supernovæ are much higher than those KamLAND has already successfully observed in the reactor measurement.

[1] K. Eguchi et al., Phys. Rev. Lett. **90**, 021820, 2003
[2] R.S. Raghavan et al., Phys. Rev. Lett. **80**, 635-638, 1998